Centers for Disease Control and Prevention

Closeout Report
For the South East Asian Environmental Initiative Associate Award

Award No. # GH-99-004, Cost Center 072
CAN GH95

December 1, 2003

COMPONENT 5: Establishment of smoke and haze conditions and health effect monitoring/analysis systems in Southeast Asia, to develop strategies to respond to and mitigate health effects on vulnerable populations

---

ASPIRATIONS

Background

Biomass burning, the burning of live or recently living vegetation to clear land for agriculture, plantations and resettlement, for the disposal of agricultural and domestic refuse, and as fuel for cooking and heating, is common in many tropical countries. Southeast Asia experienced widespread haze resulting from biomass burning in 1994, which coincided with an El Niño atmospheric pattern. A dense biomass haze lasting from July through October in 1997 affected areas of Indonesia, Malaysia, Brunei Darusssalam, Singapore, Thailand, and the Philippines. During the 1997 haze, which was attributed to a large scale biomass burning in Indonesia, again in an El Niño year, air quality measurements reached hazardous levels.

International concern for potential health effects caused by exposure to biomass burning emissions in the region prompted a request for assistance in determining the nature of transboundary haze and assessing health implications. The United States Government (USG), under the aegis of the State Department, organized an interagency working group under the South East Asian Environmental Initiative (SEA-EI) to respond to multisectoral issues related to the haze. The Centers for Disease Control and Prevention (CDC) represented the health sector in this working group. Subsequently, in February 1998, Dr. Haji Abdul Aziz Bin Mahmood, Director of Communicable Disease Control, Ministry of Health Malaysia (MOH), requested the assistance of the USG through Ambassador John Mallett in Kuala Lumpur, in assessing health effects from transboundary haze arising from the 1997-98 fires in Indonesia. CDC responded to this request under the aegis of the SEA-EI.

Theme and Purpose of Assessments

The 1997-1998 fire and haze events affecting Malaysia highlighted the need for an effective, timely, and coordinated public health response to ensure the health and safety of affected communities. An effective response, however, is predicated on baseline information of health effects for vulnerable subgroups of the population, absent in the immediate aftermath of this event.

In collaboration with the MOH, specifically the Institute for Medical Research's (IMR) Environmental Health Research Centre (EHRC) in Kuala Lumpur, CDC proposed activities consisting of two parts: 1) a health assessment of short and long term health outcomes from exposures to biomass smoke and haze, and 2) capacity building to perform the assessments. Within CDC's National Center for Environmental Health (NCEH), the Air Pollution and Respiratory Health Branch (APRHB) and the Health Studies Branch (HSB) agreed to divide the study population into two groups: 1) children = 12 years of age and pregnant women, to be addressed by HSB, and 2) adults = 50 years with cardiorespiratory conditions prior to the haze, to be addressed by APRHB.

For the assessment of children and pregnant women, the intended outcomes are to 1) conduct a comprehensive health assessment of short and long term health outcomes from short and long term exposures to biomass smoke and haze in children and pregnant women; 2) provide human and environmental exposure assessment prior to and after biomass smoke; and 3) build capacity for environmental health investigations in Malaysia. For the assessment of adults, there are three objectives: 1) to determine whether there was an increase in total hospitalizations, cardiovascular hospitalizations, and respiratory hospitalizations during the months of the forest fires in 1997 relative to the Anon-fire@ years of 1995 and 1996, adjusting for seasonal variation in admissions; 2) to assess whether cohorts of persons with previous hospital admissions for cardiorespiratory diseases were more likely to be readmitted for the same condition during the forest fires of 1997 than during the same months during pre-fire years of 1995 and 1996; and 3) to assess the duration of any longer term Apost-fire@ health effects (in the form of longer term increases in re-hospitalization rates among persons with a history of disease) in cohorts of persons exposed to the forest fire smoke. Hospitalization data provided by the Sarawak Health Department provided a unique opportunity to undertake this investigation as: a) the population density of exposed persons was sufficient to permit cohort analyses of hospitalizations, and, b) the absence of significant industrial pollution permitted an independent assessment of the health effects of forest fire smoke exposure.

EVOLUTION

Several developments from the response to the fires and haze influenced the subsequent design of the studies of short- and long term impacts. Initial briefings at a World Health Organization-sponsored meeting for six affected countries in June, 1998, held in Kuala Lumpur, provided a basis for the scope and magnitude of regional health issues from

transboundary haze. Subsequently, in cooperation with IMR, CDC engaged in a feasibility study in May-June 1999 that resulted in the identification of three study sites in the country having varying exposures to haze for the assessments. Concurrently, findings from the monitoring of ambient particles during the emergency in Borneo identified chemicals that might affect human health (e.g., heavy metals and volatile organic compounds identified by Canadian and Japanese environmental consultants). As the analysis of the data ensues, we expect cooperation with atmospheric transport modeling experts when basic analyses of the data are complete.

In tandem with technical developments, administrative requirements for conducting research were observed by CDC and IMR. Study protocols were submitted and approved by CDC's Institutional Review Board with approval granted in the fall of 1999, and by the MOH in September 2000. A Cooperative Project Assurance outlining protection of human subjects necessitated approval from the U.S. Department of Health and Human Services (DHHS)' Office of Human Research Protections and the Ministry of Health Malaysia and granted in May 2001.

Finally, the Asia Pacific Economic Cooperation (APEC) sponsored the activity, "Health Assessment and Prevention Related to Forest Fires: Population Exposures and Associated Health Impacts," under its Industrial Science and Technology Working Group. The proposing APEC member was the United States, with co-sponsors Malaysia and Mexico. The sponsorship recognized the merits of the collaborative activity between the countries with study results having regional and international ramifications for preventing and mitigating transboundary haze.

RESULTS

Input Delivery

In May 17-June 6, 1999, a joint team from CDC and IMR evaluated the feasibility of (1) an environmental exposure assessment and selected health outcomes related to the constituents of haze among children < 12 years of age, and (2) maternal exposures to haze during periods of pregnancy and birth outcomes. Because levels of exposure to haze varied across the country, the team traveled to 9 areas in 7 states and the federal district of Kuala Lumpur to assess appropriate field sites for conducting the overall assessment: Kuala Lumpur, Sarawak, Sabah, Pahang, Johor, Kelantan, Kedah, and Penang.

In September 2001, the team conducted three studies. First, we retrospectively reviewed clinic records of children aged 12 years or younger with selected respiratory and ophthalmologic conditions to document these conditions. Second, we conducted a baseline cross-sectional study to obtain current biologic and environmental exposures to the constituents of haze among children aged 12 years or younger, identified from the retrospective study. The baseline included a cross-sectional household survey of the

homes of selected children to risk factors for respiratory and ophthalmologic illnesses related to the haze period and a medical assessment of the study children that included pulse oximetry, peak-flow testing, and a standard eye examination. In addition, the study children provided biologic samples which were analyzed for selected volatile organic compounds (VOCs), heavy metals, and polycyclic aromatic hydrocarbons (PAHs). Environmental samples were collected in water, soil, and household dust media; additionally, the study children wore 3M™ 3510 organic vapor monitoring (OVM) badges on their clothing for at least 8 hours to provide readings of VOCs in the immediate environment. Finally, we retrospectively reviewed records of pregnant women and their newborns to determine relations between maternal exposure to haze during periods of pregnancy and adverse birth outcomes, primarily low birth weight. The studies were undertaken in three areas of the country: 1) Lubok Antu, Sarawak, where acute exposures occurred from peat-based fires in Kalimantan, Indonesia; 2) Pontian, Johor, where chronic exposures occurred from vegetation fires in Sumatra, Indonesia; and 3) Kota Bharu, Kelantan, which experienced little to no exposure to transboundary haze.

On the basis of the hypothesis that exposure to an air pollutant is associated with an increase in respiratory illness and eye disorders, we calculated a sample size of 214 participants per site for an anticipated probability of one of these diseases to be 40% for no exposure, an anticipated relative risk worth detecting at 1.5, and a power of 80% with alpha error of 5%. The anticipate probability of 40% for no exposure was based on data indicating that respiratory diseases accounted for 38.1%, 39.9%, and 42.5% of the 15 principal causes of new attendances at a general outpatient departments in hospitals in peninsular Malaysia, Sabah, and Sarawak, respectively, in 1996 (Ministry of Health Malaysia, 1996). At the request of the environmental health laboratory division at CDC, however, we modified the sample size for the baseline cross-sectional study from 214 to 75 per site, for a total of three study sites to accommodate logistical and financial resources. We obtained assurance of compliance for the protection of human research subjects from the Ministry of Health Malaysia and the United States (U.S.) Department of Health and Human Services.

In the event of a future transboundary haze episode of significant proportions, a fourth study—a prospective cohort study of children aged 12 years or younger from the most severely haze-affected area—is planned to determine exacerbation in respiratory and ophthalmologic conditions. Biological and environmental sampling of the study children and their homes are anticipated as part of the study.

We also obtained air monitoring information—carbon monoxide, ozone, particulate matter, sulfur dioxides, nitrous oxides, methane, metals, daily ambient temperature, wind speed, and others—from selected monitoring stations in the study areas during the haze period to correlate with respiratory, ophthalmologic, and birth outcomes and to compare these with similar data from 1996 and 1998. These data have been made available to the IMR by various environmental and meteorological government agencies in the country.

Findings from the adult study indicate that statistically significant increases in respiratory hospitalizations were probably fire-related, specifically those for Chronic Obstructive Pulmonary Disease (COPD) and asthma. The survival analyses indicated that persons over age 65 years with previous hospital admissions for any cause ($P2_{1df}$,= 5.98, p=.015), any cardiorespiratory disease ($P2_{1df}$,= 5.3, p=.02), any respiratory disease ($P2_{1df}$,= 7.8, p=.005), or COPD ($P2_{1df}$,= 3.9, p=.047), were significantly more likely to be rehospitalized during the follow-up period in 1997 than during the follow-up periods in the pre-fire years of 1995 or 1996. The survival functions of the exposed cohorts resumed similar trajectories to unexposed cohorts during the post-fire period of November 1, 1997 - December 31, 1998.

Current Study Status

1. *Retrospective study of clinic records of children aged 12 years or younger*

We reviewed 1,181 records of respiratory and ophthalmologic conditions that occurred during the study period (June-November 1997); and for comparison periods (June-November 1996 and June-November 1998) from health clinics in Lubok Antu. We also collected 973 and 1,142 such records from Pontian and Kota Bharu, respectively. In addition to demographic data, we abstracted diagnostic and treatment information in an attempt to identify the types and quantities of medication and supplies that might be needed in a similar future haze emergency. A medical school graduate was recruited specifically to review and systematize diagnostic and treatment categories.

At this writing, data cleaning and analysis are in progress.

2. *Baseline cross-sectional study*

We enrolled 59, 75, and 71 study children and their households in Lubok Antu, Pontian, and Kota Bharu, respectively. Using a standardized form, clinical personnel assessed the medical status of each study child for anthropometrics, pulse oximetry, peak-flow testing, and vision. The study children provided urine and blood samples for measurement of baseline levels of VOCs, PAHs, and inorganics (lead, arsenic, and cadmium), and wore a 3M™ OVM badge for at least 8 hours. We completed analyses for whole blood specimens for 31 VOCs and for urine samples for 16 mono-hydroxy metabolites of PAHs. Analyses of blood lead and blood cadmium have been completed. Analyses of 3 VOCs—benzene, styrene, and toluene—in diffusional monitor badges have been completed using the 3M™ OVM test method.

From 12 households selected by convenience throughout the three sites, we collected samples of drinking water, soil outside the immediate vicinity of the residential structure, and dust wipes from inside the home. Soil samples were analyzed by DataChem Laboratories, Inc. in Salt Lake City, Utah, USA, for PAHs (U.S. Environmental Protection Agency [EPA], 1986) and metals (U.S. EPA, 1996). Dust wipes were

analyzed for PAHs (National Institute for Occupational Safety and Health [NIOSH] of the CDC, 1994), and for arsenic, cadmium, and lead (NIOSH, 1994). Water samples were analyzed by the Water Quality Laboratory of the U.S. Geological Survey (USGS) in Denver, Colorado, USA for PAHs by gas chromatography-electron-impact mass spectrometry (USGS, 1987) and for metals by dissolved inductively coupled plasma-mass spectrometry (USGS, 1993 and 1999).

At this writing, analyses of arsenic in urine samples are in progress. Data cleaning and analysis are in progress.

3. Retrospective study of records of pregnant women and their newborns

We collected 2,317 records of pregnancy outcomes from prenatal clinics at the district level in Lubok Antu, Pontian, and Kota Bharu during the study periods (October 1997, =January 1998, and April 1998) to assess 3rd, 2nd, and 1st trimester exposures to haze, respectively. We obtained similar data for comparison periods---October 1998, January 1999, and April 1999. The records provided information about demographics and socioeconomic status of the mother, obstetric and pregnancy histories, complications or special care, delivery record, and maternal and infant complications.

Data analyses are ongoing.

4. Prospective cohort study of children aged 12 or younger

The study protocols planned for a fourth study in the event of a future transboundary haze episode of significant proportions to determine exacerbation in respiratory and ophthalmologic conditions. However, the funds remaining after the completion of Studies 1-3 are insufficient to support this fourth study. We expect that after field-based investigations afforded by Studies 1-3, the national and local capacities to conduct Study 4 are adequate. CDC may provide laboratory support, if needed.

5. Adult Study

This study has been completed. A final report was sent to the Malaysian Ministry of Health and is attached to this document. A manuscript of findings from the adult study is currently under submission to the *International Journal of Hygiene and Environmental Health.*

Outputs to date

In line with the SEA-EI, activities to date have provided: 1) strengthening of epidemiologic and laboratory-based field-based capacities at national and local levels for conducting environmental health investigations in response to major haze events; 2) baseline measurements of chemicals in young children in their environments in Malaysia that would provide reference standards for comparing exposures in future haze episodes; 3) training of local Malaysian staff in conducting exposure assessments; and 4) completion of a final report on cardiorespiratory health effects of smoke exposure from the 1997 Southeast Asian Forest Fires among persons who were hospitalized in the region of Kuching, Malaysia.

BUDGET

Of $8,835,500 awarded to CDC's Office of Global Health, $270,000 was allocated from the SEA-EI and provided to NCEH. Expenditures were dependent on the activities that conducted for a particular year. Noteworthy costs included $31,446 to IMR in April 2001 in anticipation of set-up costs for the field investigation, and $91,232 to NCEH's Division of Laboratory Sciences for analysis of samples in October 2003. A general breakdown is presented as follows:

Original Agreement	270,000
Total Funding	270,000
Less 26% overhead	214,286
Minus 4%, plus 10%	226,648
Closeout FY 99 expenditures	32,991
Closeout FY 00 expenditures	8,033
Closeout FY 01 expenditures	100,184
Closeout FY 02 expenditures	176
Closeout FY 03 expenditures	91,232
Balance	0

PRODUCTS

Presentations:

Workshop on Analyses of Data Related to Haze and Public Health. "Analyses related to environmental exposures and health outcomes: the disaster approach." Port Dixon, Malaysia, June 3-4, 1999. An estimated 40 Malaysian officials (environmental and occupational health officers, medical and health assistants) from 14 states attended this event.

Development of analytical methods for polycyclic aromatic hydrocarbons metabolites in humans. Presentation by the Division of Laboratory Sciences, NCEH, CDC, to IMR staff and counterparts from the National University of Malaysia, August-September 2001.

Workshop for Hospital Records and Data Officers in Sarawak. Ensuring data quality: hospitalization data from the state of Sarawak. Presented at the Sarawak Health Department, December, 2001.

Cardiorespiratory health effects of the Malaysian forest fires: preliminary results. Presented to representatives of the Malaysian Ministry of Health, Kuala Lumpur, December, 2001.

Health assessment from transboundary haze from forest fires in Malaysia. Brown bag seminar given at NCEH/CDC, March 1, 2002.

Health effects of the Malaysian forest fires. Presentation at the Annual Meeting of the Population Association of America, Minneapolis, Minnesota, April, 2003.

The 1997 Malaysian forest fires: respiratory hospitalizations in persons with a history of chronic obstructive pulmonary disease. Presentation at the 2003 Annual Meeting of the American Thoracic Society, May, 2003.

Reports:

The Malaysia-U.S. Transboundary Haze Health Investigation Team. Health assessment among children and pregnant women in Malaysia potentially exposed to transboundary haze from the Southeast Asian forest fires: a progress report. Submitted to the Environmental Health Focus, Environmental Health Research Centre, Institute for Medical Research (IMR), Ministry of Health Malaysia, October 2003. (In press)

For the adult study, a final report entitled "Cardiorespiratory Hospitalizations Associated with Smoke Exposure During the 1997 Southeast Asian Forest Fires" was sent to the Malaysian Ministry of Health and is attached to this document. A manuscript of the same title is currently under review by the *International Journal of Hygiene and Environmental Health.*

World Health Organization (WHO) Guidelines:

Health Guidelines for Vegetation Fire Events (Guidelines, Background Papers, and Teachers' Guide). Eds. Schwela DH, Goldammer JG, Morawska LH, Simpson O. United Nations Environment Programme, WHO, World Meteorological Organization, Institute of Environmental Epidemiology, Ministry of Environment, Singapore. Singapore: WHO, 1999.

The electronic form of this document is available on CD ROM of the Health Cities Air Management Information System AMIS and, in part, from the Web site of the World Health Organization (http://www.who.int/) and the Global Fire Monitoring Center (http://www.uni-freiburg.de/fireglobe).

Additional publications and presentations are anticipated when data analysis and writing are completed for Studies 1-3.

CONCLUSION

This investigation represents an extensive and concerted effort to characterize the relation between the exposure to the constituents of haze during 1997-98 haze episodes and respiratory and ophthalmologic morbidity, as well as effects on maternal exposure in defined areas of Malaysia. Furthermore, this effort provides baseline information against which to compare exposures to haze in subsequent events, and estimates of exposure or dose used to quantify the relation between exposure to haze and the health status of individuals. Results from the baseline study also may be used to develop reference ranges for environmental exposures to toxic chemicals, such as lead and arsenic, among young children in Malaysia and in Asia, where reference ranges currently do not exist in the scientific literature as related to haze exposures.

During the cross-sectional baseline study, we modified the protocols to reflect economic and logistical constraints. One modification was to reduce the sample size of the study children from 214 to 75 per site. Although this may affect statistical significance, descriptive results, rather than statistically significant analyses, from pediatric environmental exposures were important in providing baseline data from the study sites.

We attempted to conduct a standard set of exams among the study children. However, two of the three medical teams per site did not have access to special equipment, such as pulse oximeters; consequently, pulse oximetry was performed on approximately 1/3 of the study children in each site. Because the children were visited by geographic proximity, selection bias may affect the generalizability of results.

We began the overall investigation with a standardized set of questions for the baseline cross-sectional and household exposures study. However, cultural differences necessitated modification of questions, particularly in Lubok Antu, where the residents lived in longhouses, rather than in single-family dwellings as in Pontian and Kota Bharu. Interpreting and comparing responses from Sarawak (Lubok Antu) and peninsular Malaysia (Pontian and Kota Bharu) may require careful consideration of cultural practices, such as household cooking and pesticide application.

Finally, we noted that air monitoring sites were located at varying distances from residences in the study areas. Quantifying exposures and relating them to individuals' dose-response may roughly approximate rather than accurately reflect exposure assessment. In addition, some monitoring stations expanded their complexity of chemicals to monitor several months after the haze event in 1997-98. Comparing levels of selected chemicals during 1996 and 1997 with those of 1998 may not be possible.

Conclusions from the adult study indicate that communities exposed to forest fire smoke during the Southeast Asian forest fires of 1997 experienced short-term increases in cardiorespiratory hospitalizations. When an air quality emergency is anticipated, persons over age 65 with histories of respiratory hospitalizations should be preidentified from existing hospitalization records and given priority access to interventions.

Next Steps

Since the fall of 2001, we have been cleaning and systematizing information from the three studies in the three sites throughout the country. A statistician has been contracted to manage the databases in preparation for analysis. We also are exploring the possibility of atmospheric transport modeling, in consultation with meteorologists from the U.S. National Oceanic and Atmospheric Administration, to track environmental exposures to haze constituents. A complete analysis is expected in 2004.

References

Baird and Associates, 1999. (personal communication).

Benedict I. Ministry of Health Malaysia. Country Report Malaysia. Presented at the WHO biregional workshop on health impacts of haze-related air pollution. Kuala Lumpur, Malaysia, 1-4 June 1998.

Brauer M. Health impacts of biomass air pollution. Report prepared for the WHO biregional workshop on health impacts of haze-related air pollution. Kuala Lumpur, Malaysia, 1-4 June 1998.

Ismail IS, Yamamura S. Haze monitoring by the Environmental Management Center, Indonesia. Unpublished report. Presented at the WHO biregional workshop on health impacts of haze-related air pollution. Kuala Lumpur, Malaysia, 1-4 June 1998.

Levine JS. The 1997 fires in Kalimantan and Sumatra, Indonesia: Gaseous and particulate emissions. Geophysical Research Letters. In press.

Ministry of Health Malaysia. Annual report 1996. Kuala Lumpur, Malaysia: Department of Public Health, 1996.

National Institute for Occupational Safety and Health (NIOSH). NIOSH Manual of analytical methods (NMAM®), 4th ed. Atlanta: U.S. Department of Health and Human Services, CDC, NIOSH. Publication 94-113, August, 1994. Cassinelli ME & O'Connor PF, eds. (Method 5506 mod)

National Institute for Occupational Safety and Health (NIOSH). NIOSH Manual of analytical methods (NMAM®), 4th ed. Atlanta: U.S. Department of Health and Human Services, CDC, NIOSH. Publication 94-113, August, 1994. Cassinelli ME & O'Connor PF, eds. (Method 7300)

3M™ Data Bulletin. Organic vapor monitor sampling and analysis guide. St. Paul, Minnesota USA: 3M™ Occupational Health and Environmental Safety Division, June 1, 2000.

U.S. Environmental Protection Agency. Polynuclear aromatic hydrocarbons. CD-ROM, September 1986. (Method 8310).

U.S. Environmental Protection Agency. Index to EPA test methods. Inorganics by ICP-atomic emission spectroscopy, 1996. April 2003 revised edition. (Method 6010B Trace).

U.S. Geological Survey. Open File Report 92-634. Faires LM, 1993, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory--Determination of metals in water by inductively coupled plasma-mass spectrometry: U.S. Geological Survey Open-File Report 92-634, 28 p. (Method ID: I-2477-92).

U.S. Geological Survey. Open File Report 99-093. Garbarino JR, 1999, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory -- Determination of dissolved arsenic, boron, lithium, selenium, strontium, thallium, and vanadium using inductively coupled plasma-mass spectrometry: U.S. Geological Survey Open-File Report 99-093, 31 p. (Method ID: I-2477-92).

U.S. Geological Survey. Techniques of Water Resources Investigations book 5. Wershaw RL, Fishman MJ, Grabbe RR, Lowe LE, eds.,1987, Methods for the determination of organic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A3, 80 p. (Method ID: O-3118-83).

World Health Organization. Report. Biregional workshop on health impacts of haze-related air pollution. Kuala Lumpur, Malaysia, 1-4 June 1998.